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54 Magnetic recording medium.

57 A magnetic recording medium is disclosed which comprises a support having formed thereon a magnetic layer containing a magnetic metallic powder with no change in its differential thermal curve up to a temperature of at least 80°C. Said magnetic metallic powder contains at least one metal which is iron, nickel and cobalt with or without at least one other element, such as Fe-Ni-Co, Fe-Mn-Zn, Fe-Co-Ni-P, Fe-Ni-Zn, Fe-Ni-Cr-P, Fe-Co-Ni-Cr, Fe-Co-P, Fe-Ni, Fe-Ni-Mn, Co-Ni, Co-Ni-P, Fe-Al, Fe-Mn-Zn or Fe-Al-P.

MAGNETIC RECORDING MEDIUM

The present invention relates to a magnetic recording medium having high resistance to oxidation, great durability to repeated still-frame operation, and high storage stability.

5           Magnetic medium generally consists of a support, shaped as a tape or sheet, of poly (ethylene terephthalate) having a magnetic layer applied, of a coating paint containing, as the two major components, magnetic particles and a binder. Magnetic particles which are metallic are  
10 superior to iron oxide particles with respect to squareness ratio, saturation magnetization and coercivity. However, metallic particles smaller than about 1  $\mu\text{m}$  are not only difficult to disperse but also are easily oxidized and corroded to cause a gradual decrease in the saturation  
15 magnetization, storage stability and durability to repeated still-frame operation. Metallic particles are highly reactive and are pyrophoric at room temperature. The instability of metallic particles against oxidation is partly due to the inherent properties of the metal, but the  
20 principal cause is said to be pinholes present in the surface of the metallic particles.

It has now been found that the surface state of metallic particles has a very close relation with the stability of the differential thermal curve of the  
25 particles.

The primary object of the present invention is to provide a magnetic recording medium having high resistance to oxidation, great durability to repeated still-frame operation, and high storage stability.

5           This can be achieved, according to the present invention, by forming on a support a magnetic layer containing a magnetic metallic powder having no substantial change in its differential thermal curve up to a temperature of at least 80°C.

10           The magnetic layer of the medium according to the present invention contains metallic particles whose differential thermal curve will not change up to a temperature of at least 80°C. Therefore, even after repeated running of the medium, the magnetic particles will  
15 not be easily oxidized and there will be no significant deterioration of the electro-to-magnetic conversion characteristics.

          The differential thermal curve of the magnetic powder remains stable up to a temperature of at least 80°C.  
20 Therefore, even if heat (av. 60-75°C) is generated by friction with the magnetic head during recording or playback, the magnetic powder remains stable enough to ensure high durability against still-frame operation.

          The magnetic powder whose differential thermal  
25 curve will not change up to a temperature of at least 80°C has high dispersibility and hence assures the production of a highly durable magnetic recording medium.

Fig. 1 is an electron photomicrograph (30,000X) of conventional metallic magnetic particles;

Fig. 2 is an electron photomicrograph of the preferred metallic particles to be incorporated in the magnetic layer of the recording medium of the present invention which have a differential thermal curve having no change up to a temperature of at least 80°C;

Fig. 3 is a schematic diagram of a metallic particle having a polymer coat;

Fig. 4 is a schematic diagram of a metallic particle the outer surface of which has been gradually oxidized; and

Fig. 5 is a graph showing the still life of a magnetic recording medium vs. the temperature at which a change was observed in the differential thermal curve of a metallic powder incorporated in the magnetic layer of that medium. Fig. 1 is an electron photomicrograph (30,000X) of a known type of metallic magnetic powder whose differential thermal curve varies from 20 to 70°C. The powder comprises relatively smooth-surfaced acicular particles overlapping each other. By contrast, it has been found, as shown in Fig. 2, that a metallic powder whose differential thermal curve does not change up to a temperature of at least 80°C produces very different results; the powder comprises acicular particles which have high surface asperity and a smaller number of pinholes, which are generally understood to make metallic particles less stable against oxidation.

This finding, which is to the effect that fewer pinholes contribute to an improved heat stability of the differential thermal curve of a particular metallic powder, and hence an improvement in its stability against oxidation, has led to  
5 the present invention.

Magnetic metallic powders that can be incorporated in the magnetic layer of the recording medium of the present invention are preferably based on iron, nickel and/or cobalt and include such alloy systems as Fe-Ni-Co, Fe-Mn-Zn,  
10 Fe-Co-Ni-P, Fe-Ni-Zn, Fe-Ni-Cr-P, Fe-Co-Ni-Cr, Fe-Co-P, Fe-Ni, Fe-Ni-Mn, Co-Ni, Co-Ni-P, Fe-Al, Fe-Mn-Zn and Fe-Al-P.

A stable metallic powder whose differential thermal curve does not change up to a temperature of at least 80°C  
15 may be prepared by one of the following methods.

- (1) The outer surface of a metallic particle (1) is provided with a coat (2) of a thermally stable polymer, for example, polyamide resin (see Fig. 3).
- (2) The outer surface of a metallic particle (1) is  
20 gradually oxidized to form a stable layer of oxide (2) (see Fig. 4).
- (3) A particular metallic powder is lattice- or surface-doped with at least one element, for example, nickel, aluminum, silicon, magnesium, copper or phosphorus and/or a  
25 compound thereof.

It is preferred that the greater part of the magnetic particles in the magnetic layer of the recording

medium of the present invention be prepared by the third method, with either the first or second method or both being used as auxiliary techniques. The magnetic powder prepared by the first method preferably has a relatively  
5 small proportion of the metallic particles per unit volume, and magnetization per unit volume of the resulting magnetic layer is hence smaller than in the case of a magnetic layer using uncoated metallic powders. A coated type magnetic recording medium has a magnetic layer which is primarily  
10 made of magnetic particles and a binder, but this type of medium is not suitable for high-density recording if the metallic powder to be incorporated in the magnetic layer is given thermal stability (or resistance to oxidation) by the first method because the resulting magnetic particles have  
15 a lower effective packing density. Moreover, the magnetic particles prepared by the first method require a special binder system (i.e. a special binder or dispersant), which leads to complicated manufacture.

The same problems occur in the magnetic powder  
20 prepared by the second method: the volume of the unoxidized part of a magnetic particle which contributes to magnetization is preferably smaller than that of the metallic portion, and this again means a low packing density (fewer magnetic particles that can be packed in a given  
25 volume of the magnetic layer).

Therefore, it is preferred that the magnetic powder to be incorporated in the magnetic layer of the

recording medium of the present invention be primarily produced by the last of the three methods described above and be characterised by the thermal stability (or resistance to oxidation) of the magnetic powder per se. If necessary, 5 this last method may be combined with either the first or second method or both.

Other methods may, of course, be used, for example immersing magnetic particles in a solution of a material (which may have a low or high molecular weight) capable of 10 filling the pinholes in the particles. Alternatively, a thin film (which may not have a high heat stability) is formed on the surface of magnetic particles by immersion or method (1), and said particles are then treated either chemically or physically to provide particles which are 15 stable to heat or oxygen. These methods may be combined with treatment by a corrosion inhibitor such as silicone oil. The only requirement for the metallic powder according to the present invention which has no change in its differential thermal curve up to a temperature of at least 20 80°C is that said powder be modified to remain stable against heat or oxygen up to a temperature of at least 80°C without impairing its magnetic characteristics significantly.

The following description primarily concerns the 25 third method wherein the metallic components of a magnetic powder (the term "metallic components" shall mean those other than carbon, hydrogen and oxygen which are not

detectable by an X-ray analyzer) are doped with various elements and/or their compounds. Preferred dopants used in this third method include aluminum, silicon and nickel, as well as compounds of these elements. The differential thermal curve of a metallic powder is obtained by determining the energy states of the powder and a reference material (e.g. thermally stable alumina or quartz) in terms of the difference in the temperature increase between the two materials which are heated together at a constant rate.

10 For more details of the method of obtaining the differential thermal curve, see, for example, "New Course in Elemental Chemistry", vol. 2, Fundamental Techniques, ed. by The Chemical Society of Japan.

If the dopant is aluminum and/or a compound thereof, it is desirably used in such an amount that the aluminum atoms ( $\text{Al}_2$  of  $\text{Al}_2\text{O}_3$ ) account for 0.5 to 20%, preferably 1 to 20%, of the atomic weight of all metallic components of the magnetic powder. If the proportion of the aluminum atoms is less than 0.5% of the atomic weight of the metallic components, the resulting magnetic powder does not have a satisfactory stability against heat or oxidation, and is unable to provide a magnetic recording medium having good performance, i.e. high storage stability, high output on playback, and great durability against repeated still-  
25 frame operation.

If elemental silicon and/or its compound is used as the dopant, it is desirably used in such an amount that



the silicon atoms account for not more than 1%, preferably not more than 0.5%, more preferably not greater than 0.1%, of the atomic weight of the metallic components (e.g. Al, Si, S, Fe, Ni, Co, Ra, Hf, Cu, P, Zn, Mn, Cr, Bi and Mg) of  
5 the magnetic powder.

If more than 1 atomic weight percent of silicon is used, the desired modification of the magnetic powder is difficult to achieve.

If elemental nickel and/or its compounds is used as  
10 the dopant, the upper limit for the nickel atoms is generally 30%, preferably 20%, of the atomic weight of the metallic components. If more than 30% of nickel is used, a recording medium having the desired magnetic characteristics generally cannot be obtained.

15 A binder may be incorporated in the magnetic layer of the magnetic recording medium of the present invention, and any known thermoplastic resins, thermosetting or reactive resins, resins that cure upon irradiation with electron beams, as well as mixtures of these resins may be  
20 used as the binder.

Suitable thermoplastic resins have a softening point of less than 150°C, an average molecular weight of 10,000 to 200,000, and a degree of polymerization of 200 to 2,000. Examples of such polymers are vinyl chloride/vinyl  
25 acetate copolymer, vinyl chloride/vinylidene chloride copolymer, vinyl chloride/acrylonitrile copolymer, acrylic acid ester/acrylonitrile copolymer, acrylic acid ester/

vinylidene chloride copolymer, methacrylic acid ester/  
ethylene copolymer, urethane elastomer, polyvinyl fluoride,  
vinylidene chloride/acrylonitrile copolymer, butadiene/  
acrylonitrile copolymer, polyamide resin, polyvinyl butyral,  
5 cellulose derivative (e.g. cellulose acetate butyrate, cellu-  
lose diacetate, cellulose triacetate, cellulose propionate,  
or nitrocellulose), styrene/butadiene copolymer, polyester  
resin, chlorovinyl-ether/acrylic acid ester copolymer, amino  
resins, various synthetic rubber thermoplastic resins and  
10 mixtures thereof.

Specific examples of these resins are given in Japanese  
Patent Publications Nos. 6877/62, 12528/64, 19282/64, 5349/65,  
20907/65, 9463/66, 14059/66, 16985/66, 6428/67, 11621/67,  
4623/68, 15206/68, 2889/69, 17947/69, 18232/69, 14020/70,  
15 14500/70, 18573/72, 22063/72, 22064/72, 22068/72, 22069/72,  
22070/72, and 27886/73, as well as U.S. Patents Nos.  
3,144,352, 3,419,420, 3,499,789 and 3,713,887.

The thermosetting or reactive resin is desirably such  
that it has a molecular weight of 10,000 to 200,000 when it  
20 is in coating solution and that after application and drying  
of a coating solution, its molecular weight is increased  
infinitely due to condensation, addition or other reactions.  
Preferred thermosetting or reactive resins are those which do  
not soften or melt until they are decomposed with heat.  
25 Specific examples are phenolic resins, epoxy resins,  
polyurethane curable resin, urea resin, melamine resin, alkyd  
resin, silicone resin, acrylic reactive resin, a mixture of

high-molecular weight polyester resin and isocyanate prepolymer, a mixture of methacrylic acid salt copolymer and diisocyanate prepolymer, a mixture of polyester polyol and polyisocyanate, urea-formaldehyde resin, low-molecular weight glycol/high molecular weight diol/triphenylmethane triisocyanate mixture, polyamine resins and mixtures thereof.

Specific examples of these resins are found in Japanese Patent Publications Nos. 8103/64, 9779/65, 7192/66, 8016/66, 14275/66, 18179/67, 12081/68, 28023/69, 14501/70, 24902/70, 10 13103/71, 22067/72, 22072/72, 22073/72, 28045/72, 28048/72 and 28922/72, as well as U.S. Patents Nos. 3,144,353, 3,320,090, 3,437,510, 3,597,273, 3,781,210 and 3,781,211.

Illustrative resins that cure upon irradiation with electron beams include unsaturated prepolymers such as maleic anhydride type, urethane acrylic type, epoxy acrylic type, 15 polyester acrylic type, polyether acrylic type, polyurethane acrylic type and polyamide acrylic type, as well as poly-functional monomers such as ether acrylic type, urethane acrylic type, epoxy acrylic type, phosphate ester type, aryl 20 type and hydrocarbon type.

The above listed binders may be used either alone or in combination with themselves or other additives.

The binder is typically used in an amount of 5 to 400 parts by weight, preferably 10 to 200 parts by weight, per 25 100 parts by weight of the magnetic particles of the present invention. If the binder is used in an excessive amount, the resulting magnetic recording medium has a low recording density, and if the binder content is too low, a weak

magnetic layer which is less durable and tends to break up is formed.

In order to produce a highly durable magnetic recording medium, various curing agents may be incorporated  
5 in the magnetic layer, for example, a polyisocyanate. Illustrative polyisocyanates are addition products of diisocyanate and trivalent polyols, diisocyanate pentamers, and decarboxylation products of 3 mols of diisocyanate and water. Preferred curing agents include an adduct of 3 mols  
10 of tolylene diisocyanate and 1 mol of trimethylolpropane, an adduct of 3 mols of metaxylylene diisocyanate and 1 mol of trimethylolpropane, a tolylene diisocyanate pentamer, a pentamer made of 2 mols of tolylene diisocyanate, and a decarboxylation product prepared by reacting 3 mols of  
15 hexamethylene diisocyanate and 1 mol of water. All of these compounds can easily be produced on an industrial scale.

Besides the magnetic particles, the binder and curing agent described above, the magnetic layer may contain other additives such as dispersants, lubricants, abrasives  
20 and antistats.

Examples of the dispersant are aliphatic acids, preferably having 8 to 18 carbon atoms, of formula  $\text{RCOOH}$  (wherein R is a saturated or unsaturated aliphatic group having 7 to 17 carbon atoms), such as caprylic acid, capric  
25 acid, lauric acid, myristic acid, palmitic acid, stearic acid, oleic acid, elaidic acid, linoleic acid and linolenic acid. Metal soaps made of alkali metals (Li, Na, K, etc.) or alkaline earth metals (Mg, Ca, Ba, etc.) of these

aliphatic acids, as well as lecithins may also be used as the dispersant. Higher alcohols having 12 or more carbon atoms, as well as sulfate esters of these alcohols are also usable. These dispersants and those listed above may be  
5 used either individually or in admixture preferably in an amount of 1 to 20 parts by weight for 100 parts by weight of the magnetic powder. Illustrative dispersants are given in Japanese Patent Publications Nos. 28369/64, 17945/69, 15001/73, U.S. Patents Nos. 3,587,993 and 3,470,021.  
10 Examples of the lubricant are silicone oil, carbon black, graphite, carbon black graft polymer, molybdenum disulfide, tungsten disulfide, and waxes or aliphatic acid esters of monobasic aliphatic acids having 12 - 16 carbon atoms and monovalent alcohols having a total of 21 - 23 carbon atoms  
15 as combined with the carbon atoms in said aliphatic acids. These lubricants are generally used in an amount of 0.2 to 20 parts by weight per 100 parts by weight of the magnetic powder. For specific lubricants, see Publications Nos. 23889/68 and 81543/68; U.S. Patents Nos. 3,470,021, 3,492,235,  
20 3,497,411, 3,523,086, 3,625,720, 3,630,772, 3,634,253, 3,630,772, 3,634,253, 3,642,539, and 3,687,725; IBM Technical Disclosure Bulletin Vol. 9, No. 7, page 779, December 1966; and ELECTRONIK, No. 12, page 380, 1961.

Common abrasives may be used in the present invention,  
25 and they include fused alumina, silicon carbide, chromium oxide, corundum, artificial corundum, artificial diamond, garnet, and emery (main components: corundum and magnetite). These abrasives generally have an average particle size of

0.05 to 5  $\mu\text{m}$  and a 0.1 to 2  $\mu\text{m}$  range is particularly preferred. They are preferably used in an amount of 1 to 20 parts by weight per 100 parts by weight of the magnetic powder. For more details of these abrasives, see Japanese Patent Application (OPI) No. 115510/74; U.S. Patent Nos. 3,007,807, 3,041,196 and 3,687,725; British Patent No. 1,145,349; and German Patent (DT-PS) No. 853,211.

Suitable antistats are fine particles of an electrically conductive material such as graphite, carbon black, tin oxide/antimony oxide or tin oxide/titanium oxide/antimony oxide compound, or carbon black graft polymer; a natural surfactant such as saponin; an alkylene oxide, glycerin or glycidol non-ionic surfactant; a cationic surfactant such as higher alkylamines, heterocyclic compounds (e.g. pyridine), and phosphonium or sulfoniums; an anionic surfactant containing an acidic group such as carboxylic acid group, sulfonic acid group phosphoric acid group, sulfate ester group or phosphate ester group; and an amphoteric surfactant such as amino acids, aminosulfonic acids, and sulfate or phosphate esters of aminoalcohol.

For more detailed information on the surfactants that can be used as antistats, see the following patents and references: U.S. Patents Nos. 2,271,623, 2,240,472, 2,288,226, 2,676,924, 2,676,975, 2,691,566, 2,727,860, 2,730,498, 2,742,379, 2,739,891, 3,068,101, 3,158,484, 3,201,253, 3,210,191, 3,294,540, 3,415,649, 3,441,413, 3,442,654, 3,475,174, and 3,545,974; German Patent Application (OLS) No. 1,942,665; British Patents Nos. 1,077,317, 1,198,450; "Synthesis of Surfactants and Their Applications" by Rhohei

These surfactants may be used either individually or in combination. They are generally used as antistats, but they may be used for other purposes such as increasing the dispersibility of magnetic particles, improving the magnetic characteristics, improving the lubricity of the magnetic particles, or as coating aids.

In order to prepare the magnetic recording medium of the present invention, the magnetic particles and binder described above may be mixed and dispersed in a suitable solvent so as to form a magnetic paint, which is then applied to a support and dried. The magnetic paint may also contain suitable additives such as dispersant, lubricant, abrasive and antistat. Suitable solvents for preparing the magnetic paint or those which are used to facilitate the application of that paint include ketones such as acetone, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK) and cyclohexanone; alcohols such as methanol, ethanol, propanol and butanol; esters such as methyl acetate, ethyl acetate, butyl acetate, ethyl lactate, and ethylene glycol monoacetate; ethers such as diethylene glycol dimethyl ether, 2-ethoxyethanol, tetrahydrofuran and dioxane; aromatic hydrocarbons such as benzene, toluene and xylene; halogenated hydrocarbons such as methylene chloride, ethylene chloride, carbon tetrachloride, chloroform, and dichlorobenzene.

The magnetic paint may be prepared by charging a mixer with the magnetic particles and all other ingredients simultaneously or sequentially. For instance, the magnetic particles are added to a solution containing the dispersant, 5 and the mixture is stirred for a predetermined period, and then, the other ingredients are added under stirring.

Various mixers may be used to achieve thorough mixing of the magnetic paint composition. Examples are a two-roll mill, three-roll mill, ball mill, pebble mill, sand grinder, 10 sjegvari attritor, high-speed impeller disperser, high-speed-stone-mill, high-speed impact mill, disper-kneader, high-speed mixer, homogenizer and ultrasonic disperser.

The magnetic paint prepared according to this method has a highly uniform dispersion of the magnetic 15 particles, and when their dispersibility was evaluated by the method described in the Examples that are given later in this specification, much fewer agglomerates were observed under electron microscope than in the case of the conventional magnetic paint.

20 For details of the kneading and dispersing technique, see T.C. Patton, "Paint Flow and Pigment Dispersion", John Wiley & Sons, as well as U.S. Patents Nos. 2,581,414 and 2,855,156.

For further details of the method of preparing magnetic 25 paints, see Japanese Patent Publications No. 15/60, No. 26794/64, No. 186/68, No. 28043/72, No. 28045/72, No. 28046/72, No. 28047/72, No. 31445/72, No. 11162/73, No. 21332/73 and No. 33683/73.



Suitable non-magnetic supports include polyesters such as polyethylene terephthalate and polyethylene-2, 6-naphthalate; polyolefins such as polypropylene; cellulose derivatives such as cellulose triacetate and diacetate; plastics such as polycarbonate; non-magnetic metals such as aluminum, copper, and zinc; and ceramics such as glass and "new ceramics".

The non-magnetic support may be in the form of a film, tape, sheet, disc, card drum or other suitable shapes, and a suitable material is selected from among various materials depending on its form.

The thickness of these non-magnetic supports varies with their physical shape. For films and sheets, the thickness is preferably from 3 to 100  $\mu\text{m}$ , more preferably from 5 to 50  $\mu\text{m}$ ; for disks and cards, the thickness preferably ranges from 30  $\mu\text{m}$  to 10 mm. The supports may be in a cylindrical drum shape whose specific configuration is determined by the type of the recorder with which the magnetic recording medium of the present invention is used.

The back surface (opposite the side having the magnetic coating) of the support may be provided with a protective coating for various purposes, e.g. prevention of static buildup and print-through.

For detailed information on the technique of forming the backcoat, see U.S. Patents Nos. 2,804,401, 3,293,066, 3,617,378, 3,062,676, 3,734,772, 3,476,596, 2,643,084, 2,803,556, 2,887,462, 2,923,642, 2,997,451, 3,007,892, 3,041,196, 3,115,420, and 3,166,688.

A magnetic coating is formed from the magnetic paint on a support by gravure roll coating, wire bar coating, doctor blade coating, reverse roll coating, dip coating, air knife coating, calender coating, squeeze coating, kiss coating and  
5 fountain coating. For details of these and other coating techniques, see "Coating Kogaku (Coating Engineering)", published by Asakura Shoten, March 1971, p. 258 ff., and "Plastic Films - Their Processing and Applications", published by Gihodo, 1971.

10 The magnetic coating thus formed on the support is dried after the magnetic particles according to the present invention in the coating are optionally oriented in a magnetic field. If necessary, the web with the magnetic coat may be smoothed or slit into a shape desired for the  
15 final magnetic recording medium. For the magnetic orientation, an a.c. or d.c. magnetic field having a magnetizing force of 500 to 3,000 Gauss is preferred. The web is subsequently dried, preferably at a temperature of 50 to 100°C for a period of 3 to 10 minutes. Other  
20 methods suitable for use in the present invention to orient the magnetic particles magnetically are found in various patents such as U.S. Patents Nos. 1,949,840, 2,796,359, 3,001,891, 3,172,776, 3,416,949, 3,473,960, and 3,681,138; Japanese Patent Publications Nos. 3427/57, 28368/64, 23624/  
25 65, 23625/65, 13181/66, 13043/73 and 39722/73.

The specific method of magnetically orienting the metallic particles in the magnetic layer of the recording medium of the present invention is determined by the use of

that medium.

The following working examples and comparative examples, in which all "parts" are by weight further illustrate the present invention.

5

# EXAMPLES 1 to 6

## (1) Preparation of magnetic paints

Six samples of magnetic composition each having the formulation shown below were prepared using Fe-base metallic powders (Fe  $\leq$  60 atm. wt.%) respectively having Al contents of 1.3, 3, 3.5, 4.2, 5.1 and 7.0 atm. wt.%. The first three powders had a Si content of 0.5 atm. wt.% or below, and the powder with 4.2% Al had a Si content of 1 atm. wt.% or less. The Al and Si contents of the respective powders were measured with an X-ray microanalyzer, "X-556" Model KEVEX-7000 of Hitachi, Ltd.

15

<u>Components</u>	<u>Amount (parts)</u>
Fe-base metallic powder	100
VAGH (vinyl chloride-vinyl acetate copolymer of Union Carbide Corporation)	10
Estan 5701 (polyurethane resin of B.F. Goodrich Chemical Co.)	10
Lecithin	3
MEK	70
Toluene	60
Cyclohexanone	5

20

The six metallic powders having Al contents of 1.3, 3, 3.5, 4.2, 5.1 and 7.0 atm. wt.% were characterized by such properties that their differential thermal curves would not change up to respective temperatures of 83, 86, 88, 95, 97 5 and 130°C.

The components shown above were thoroughly mixed and dispersed with a ball mill. To each of the dispersions, 5 parts of Collonate L (polyisocyanate solution of Nippon Polyurethane Industry Co., Ltd.) was added and intimately 10 mixed to provide six samples of magnetic paint which were given identification numbers 1 to 6 according to the Al contents (in the increasing order) of the metallic powders.

#### (2) Preparation of magnetic recording mediums

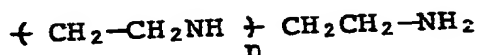
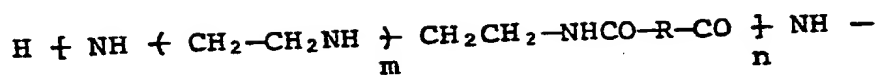
The respective magnetic paint samples were applied to 15 one side of six polyethylene terephthalate film bases (12  $\mu$  thick) to give a magnetic coating in a dry thickness of 5  $\mu$  while the magnetic particles were oriented in a magnetic field of 2,000 Gauss.

The resulting broad webs were supercalendered and slit 20 into six 12.65 mm-wide video tape samples, which were identified by Nos. 1 to 6 according to magnetic paint samples Nos. 1 to 6.

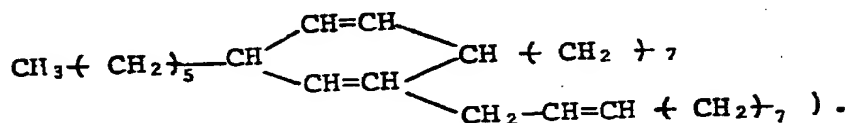
#### EXAMPLES 7 AND 8

Two samples of metallic powder (100 parts) containing 25 0.8% and 1.3% of Al were each dispersed in 670 parts of a 0.2% methylene chloride/toluene (70:30) solution of Tomide

#220 (product of Fiji Kasei K.K.) having the following formula:



5 (wherein R is



Each of the dispersions was filtered and the resulting magnetic powder was re-dispersed in 300 ml of a mineral oil ("Isopar"). After adding a solution consisting of toluylene diisocyanate (2 parts) and Isopar (60 parts), the resulting mixture was heated at 50°C for 1 hour. The magnetic powders obtained by filtration were washed with n-hexane and dried in a nitrogen atmosphere, thereby providing two samples of coated magnetic powder having differential thermal curves which were stable up to 120°C and 140°C, respectively.

15

Using these two magnetic powders, video tape samples Nos. 7 and 8 which were 12.65 mm wide were prepared by repeating the procedure of Example 1.

Example 9

Fe-base metallic particles (Al: 2 atm. wt.%) were gradually oxidized on their surface to provide a magnetic powder having a differential thermal curve that would not change up to 93°C. This powder was used to prepare a video tape sample No. 9 (12.65 mm wide) by repeating the procedure of Example 1.

Example 10

Fe-base metallic particles (Al: 3.5 atm. wt.%) were surface-treated with silicone oil to provide a rustproof magnetic powder having a differential thermal curve that would not change up to 100°C. This powder was used to prepare a video tape sample No. 10 (12.65 mm wide) by repeating the procedure of Example 1.

Comparative Example 1

Comparative video tape sample No. 1 which was 12.65 mm wide was prepared as in Example 1 except that the magnetic powder was made of only conventional Fe-base metallic particles whose differential thermal curve was stable up to 25°C.

Comparative Example 2

Metallic particles (with a differential thermal curve that would easily change at room temperature) were given a silicone oil coat to provide a magnetic powder having a

differential thermal curve that would not change up to 50°C. This powder was used to prepare comparative video tape sample No. 2 (12.65 mm wide) by repeating the procedure of Example 1.

The metallic particles used in Comparative Example 1 and 5 those used in Comparative Example 2 (before they were coated with silicone oil) were found to have the following compositions by determination with an X-ray microanalyzer, "X-556" Model KEVEX-7000 of Hitachi, Ltd.:

Magnetic powder used in Comparative Example 1

10      Si: 1.1 atm.wt.%  
         Ni: 6.8 atm.wt.%  
         Al: undetected.

Magnetic powder used in Comparative Example 2

         Si: 3.0 atm.wt.%  
15      Ni: 5.0 atm.wt.%  
         Al: undetected.

Comparative Example 3

Metallic particles were gradually oxidized on their surface to provide a magnetic powder having a differential 20 thermal curve that would not change up to 73°C. This powder was used to prepare a comparative video tape sample No. 3 (12.65 mm wide) by repeating the procedure of Example 1.

The performance of video tape samples Nos. 1 to 10 and comparative samples Nos. 1 to 3 was evaluated by checking 25 the durability to repeated still-frame operation (still life), saturation magnetization (Bm) and storage stability. The results are shown in Table 1.

Table 1

Performance Tape No.	Still life (min)	Bm (Gauss)	Bm after storage (Gauss)	Percent remanence after storage
Sample 1	> 60	3,500	3,250	93
2	> 60	3,500	3,300	94
3	> 60	3,400	3,250	96
5 4	> 60	3,200	3,150	98
5	> 60	3,100	3,050	98
6	> 60	2,900	2,850	98
7	> 60	2,950	2,850	96
8	> 60	2,900	2,800	96
10 9	> 60	3,000	2,900	96
10	> 60	3,300	3,150	96
Comparative Sample 1	< 1	3,600	2,200	60
2	< 3	3,000	2,600	86
3	15	3,900	2,500	86

15 Still life: The time (in minutes) until a 2 dB drop occurred in the playback output of a still image.

Bm : The saturation magnetization of a sample tape as measured in Gauss.

Bm after storage: The saturation magnetization (in Gauss) of a sample tape that was left to stand for 1 week at 50°C and 90% r.h.

Percent remanence after storage: Bm after storage compared with Bm before storage taken as 100%.



The still life characteristics of tape samples Nos. 1 to 10 were plotted against the stability temperatures of the differential thermal curves of the magnetic powders used in the respective samples, and the results are shown by characteristic curve a in Fig. 5, from which one can see that the tape samples using magnetic powders having differential thermal curves that remained stable up to 80°C had an appreciably long still life.

CLAIMS

1. A magnetic recording medium comprising a support which has formed thereon a magnetic layer comprising a magnetic metallic powder having no substantial change in its differential thermal curve up to a temperature of at least 80°C.

2. A magnetic recording medium according to Claim 1, wherein said magnetic metallic powder comprises an alloy system of at least one metal, which is iron, nickel or cobalt, with or without at least one other element.

10 3. A magnetic recording medium according to Claim 2, wherein said alloy system is Fe-Ni-Co, Fe-Mn-Zn, Fe-Co-Ni-P, Fe-Ni-Zn, Fe-Ni-Cr-P, Fe-Co-Ni-Cr, Fe-Co-P, Fe-Ni, Fe-Ni-Mn, Co-Ni, Co-Ni-P, Fe-Al, Fe-Mn-Zn or Fe-Al-P.

4. A magnetic recording medium according to any  
15 of Claims 1 to 3 wherein said magnetic metallic powder has a coat of thermally stable polymer, has an outer thermally stable layer of oxide or is lattice- or surface- doped with at least one other element or compound.

5. A magnetic recording medium according to any  
20 one of the preceding Claims wherein the magnetic metallic powder is lattice- or surface- doped with at least one of: nickel, aluminum, silicon, magnesium, copper, phosphorus, or a compound thereof.

6. A magnetic recording medium according to Claim 5 in which the dopant is aluminum or a compound thereof present in an amount of 0.5 to 20% by weight of aluminum atoms relative to the total weight of all metallic components of the magnetic powder.

7. A magnetic recording medium according to Claim 5 in which the dopant is silicon or a compound thereof present in an amount of not more than 1% by weight of silicon atoms relative to the total weight of all metallic components of the magnetic powder.

8. A magnetic recording medium according to Claim 5 in which the dopant is nickel or a compound thereof present in an amount of not more than 30% by weight of nickel atoms relative to the total weight of all metallic components of the magnetic powder.

9. A magnetic recording medium according to any one of the preceding Claims also comprising one or more of a binder, a curing agent, dispersant, lubricant, abrasive or antistat.

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FIG. 1.



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FIG.2



Fig. 3

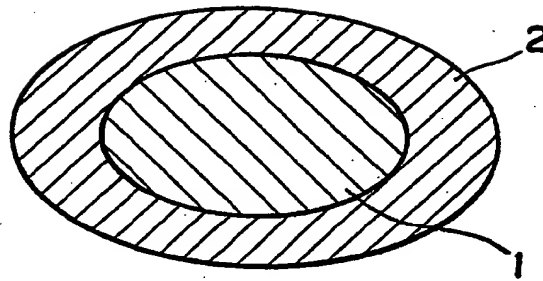


Fig. 4

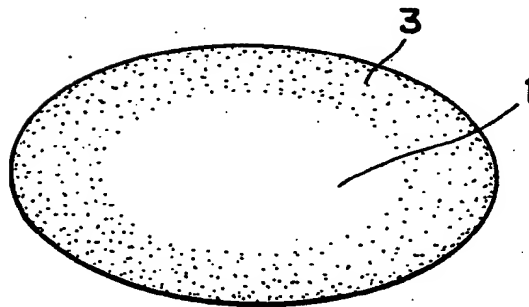
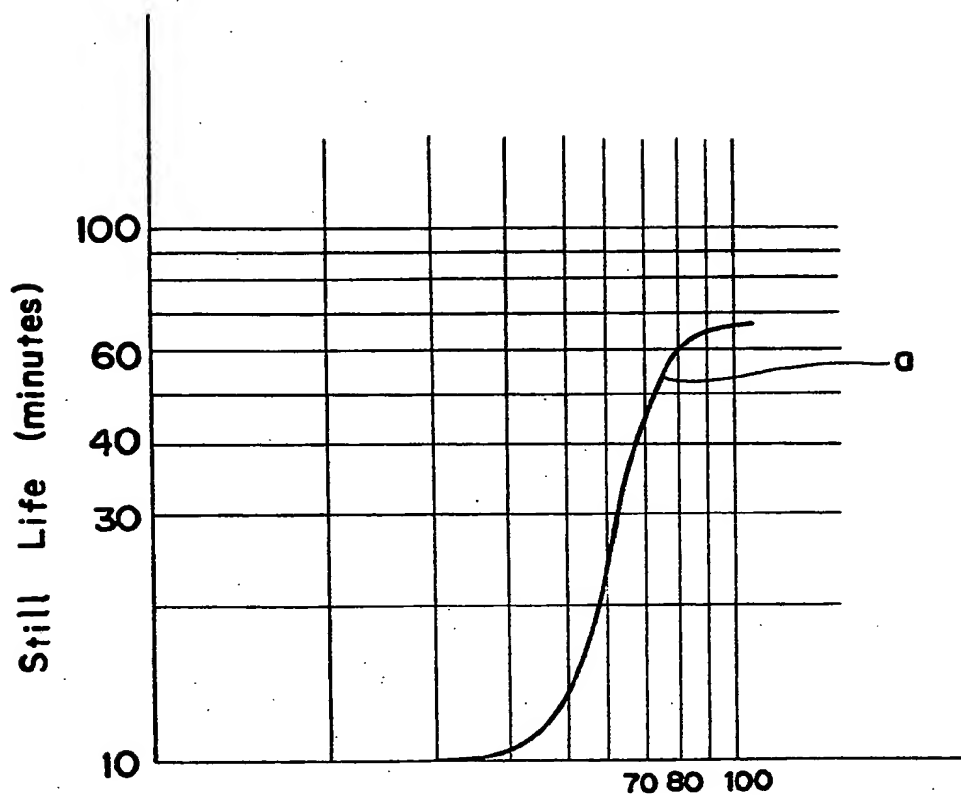


Fig. 5



Temperature at which a change was observed  
in the differential thermal curve (°C)

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